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RATIO OF ENERGY CONSUMPTIONS IN MARMMOTS AND DESERT TURTLES IN THE ACTIVE STATE, IN HYPOBIOSIS AND ARTIFICIAL AWAKENING

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Abstract: the article shows that hypobiosis is accompanied by a sharp suppression of gas-energy metabolism, which is much more pronounced in turtles, and that during hypobiosis, there is a repeated suppression of metabolism in the body of animals, which is reflected in metabolic processes in tissues, including the cellular level.
Key words: active state, hypobiosis, metabolic rate, gas-oxygen exchange, forced awakening, transaminase activity.

In view of the relatively poor knowledge of the comparative characteristics of the metabolic rate of warm and cold-blooded organisms in an active state, with hypobiosis and artificial awakening, we devoted a special series of experiments to this issue. For comparison, Menzbier's marmot and desert turtle (Testudo horsfieldi) were selected as animals with similar masses. At the same time, animals were used during the active period of life (May, June) and during the period of hypobiosis (January, February). Gas-oxygen exchange measurements were carried out in a sealed chamber.

The data obtained are shown in Table 1, from which it follows that the highest intensity of oxygen consumption by the whole organism is characteristic of animals of the active period of life. When comparing a marmot with an active turtle, more than an 8-fold difference was noted in this indicator, and it is higher in the marmot.

Data obtained on animals with hypobiosis are of considerable interest. In this state, as follows from the results of the table, more than a 30-fold decrease in gas-oxygen exchange was revealed in marmots, but in tortoises in a torpid state, a similar decrease is more than 100 times. These results show that hypobiosis is accompanied by a sharp suppression of gas-energy metabolism, which is much more pronounced in turtles.

It should be noted that the literature contains a significant amount of data on the suppression of metabolic intensity during natural hibernation, but they mainly analyze warm-blooded organisms. The comparative data we have obtained allow us to note that hypobiosis is more significantly reflected in the metabolism of a cold-blooded organism, which, apparently, is due to the special nature of the metabolism of these animals.

Table 1.
The ratio of the intensity of gas exchange (ml O2 / kg per 1 hour) in marmots and turtles during the period of activity, in a state of hypobiosis and artificial awakening (AI) (n = 8-16)

Condition	LIVING			
animals	**marmot (C)**	**turtle (h)**	**C/H**	**rat**
active (A)	849,3±97,4	203,2±16,70*	4,18	1221,2±73,2
hypobiosis (H)	23,3±2,93	1,51±0,66	15,43	
A/h	36,45	134,6		
AI	304,3±28,3	192,73±3,20	1,6	
***A/* AI**	2,79	0,9		

* The indicator was first obtained at 25 ° C, and then extrapolated to 37 ° C, taking into account the Van't Hoff temperature coefficient, taken as 3.0.

In particular, cold-blooded animals are more resistant to hypothermia and hypoxia (6,12), which is probably due to the ability of turtles to dramatically decrease metabolic processes. Therefore, we can think that a hypobiotic sharp decrease in the intensity of energy in turtles is one of the manifestations of the high resistance of these animals to extreme environmental conditions.

When conducting research in one of the series of experiments, animals were forced to awaken by placing them in a heat (thermostat). Before the onset of forced awakening, the animals were in a state of hypobiosis: body temperature in marmots was about 6 ° C, in turtles - about 4 ° C. After two days in an environment with a temperature of 250C, the body temperature of marmots increased to 320C, and in turtles - up to 21-230C. Determination of gas-oxygen metabolism in these animals showed a significant increase in the rate of metabolic processes: in marmots - by 5.3 times, and in turtles there was an almost complete restoration of initial respiration (Table 1).

Comparison of the degree of suppression of gas-oxygen metabolism in the studied animals in percentage terms is quite indicative. So, during hypobiosis, marmots consume 3% of oxygen from the level of the animal's active state, turtles - only 0.7%, i.e. much lower than marmots. However, under conditions of forced awakening, the value of this indicator reaches 36% and 96%, respectively, for marmots and turtles. Consequently, in warm-blooded animals, both in the state of winter hypobiosis and during their artificial awakening, the level of gas-energy metabolism is maintained at a level significantly lower than in active animals.

On the basis of these experiments, it can be seen that in the case of warm-blooded animals, the observed degree of metabolic activation under these conditions does not provide a complete restoration of the metabolic level characteristic of the active (summer) period of life. It can be assumed that the mechanisms that function in hypobiotic animals are not eliminated by an artificial increase in their body temperature and they partially retain their influence on the metabolic rate.

It is known that during hypobiosis there is a repeated suppression of metabolism in the body of animals (1,2), which is reflected in metabolic processes in tissues, including the cellular level (11,3,4,5). However, the available information is insufficient to judge the complex physiological and biochemical changes occurring in the body during hypobiosis, in particular, in protein-lipid-carbohydrate metabolism. Taking this into account, we considered it expedient to analyze a number of blood parameters in order to gain a more complete picture of the direction of the changes occurring during hypobiosis in mammals (marmots) and reptiles (turtles) during their stay in a state of hypobiosis. In table-2, we show the results of measuring the content of glucose, total protein and lipid metabolism components in the blood serum of these animals in an active state, and in Fig. 1, the change in the same blood parameters in marmots and turtles in a state of hypobiosis (6,7,8).

It should be noted that our experiments were carried out in the winter period of the season of the year, when the experimental animals were in a state of hypobiosis, and also in the spring-summer period, when the bauternants were active. For comparison, we also studied similar indicators in laboratory rats.

From Fig. 1, it follows that in marmots under conditions of hypobiosis, a decrease in blood glucose by about 1/3 occurs against the background of an increase in total lipids. In turtles, there is a more significant decrease in glucose levels, and the content of total lipids increases approximately to the same extent as in the case of marmots.These results indicate that changes in carbohydrate and lipid metabolism in mammals and reptiles under conditions of hypobiosis differ only quantitatively.

In accordance with the literature data (11), during hypobiosis for energy purposes, the utilization of fatty acids, which are a product of lipid metabolism, increases.The level of triglycerides and ?-hydroxybutyric acid in plasma can serve as a useful and informative physiological marker of the condition. The triglyceride level upon emergence of snakes from hibernation after months of natural aphagia was significantly higher in females, which correlates with a higher body weight per unit length.

Table 2.
Serum glucose, lipids and total protein rats, active marmots and turtles

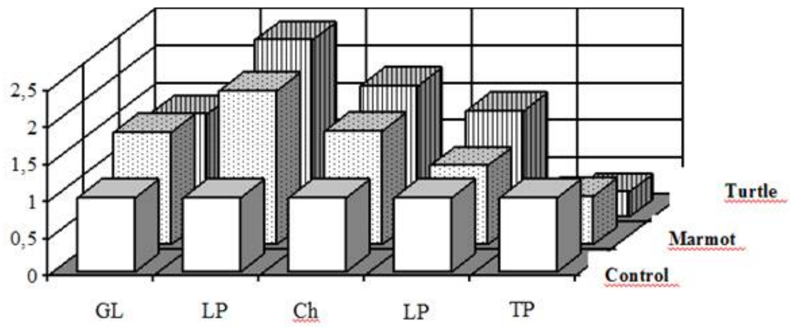
Indicators	Rat	Marmots	Turtles
Glucose (mmol/L)	3,20±0,38	8,23±0,05	8,22±0,40
Total lipids (T/l)	6,60±0,14	5,88±0,29	8,40±0,26
lipoproteins (units)	0,38±0,01	0,26±0,05	0,38±0,01
Cholesterol (mmol/L)	3,70±0,16	4,50±0,27	4,80±0,13
Total protein (T/P)	66,3 ±4,18	56,0 ±3,02	42,7 ± 3,21

In connection with the data on the important role of lipid metabolism components in the energy supply of the body during hibernation, we studied the content of a number of other lipid compounds in the blood serum of experimental animals, in particular, β-lipoproteins and cholesterol.

According to the results shown in Fig. 2, during hypobiosis in marmots there is a twofold increase in the content of β-lipoproteins, while in turtles a 2.5-fold increase in their level is revealed. In addition, in the blood of animals with hypobiosis, the content of cholesterol increases 1.5-2 times, which also reflects the state of lipid metabolism under these conditions.

These results are quite consistent with the point of view of many authors already mentioned above, that during hypobiosis, the body's lipids are intensively mobilized as an energy source (4, 5).

In connection with the above, it was of interest to assess the state of protein metabolism. In particular, we investigated the content of total proteins in the blood serum. At the same time, we revealed only a slight decrease in this indicator in the blood of marmots during hibernation. There are similar data in the literature (Khankeldiev et al.,). In turtles under these conditions, the protein in the blood is increased by 40%. Apparently, hypobiosis has little effect on the level of blood proteins in warm-blooded animals, however, the state of this indicator is more pronounced in cold-blooded animals (Fig. 1).



Picture 1.The relative change in the content of glucose, lipids and total protein in the blood of marmots and turtles under conditions of hypobiosis.

The ordinate is the relative value of the corresponding indicators during hypobiosis, in the active state taken as 1.0 (control).

Legend: G - glucose, GL - general lipids, LP - lipo proteids,
Ch - cholesterol, TP - total protein.

It should be noted that protein-nitrogen metabolism during hibernation, in all likelihood, is one of the well-homeostasized blood parameters. However, this does not mean that there are no changes in the protein composition of the blood, as evidenced by the above data on turtles. In this regard, the results of studying the activity of transaminase enzymes - alanine aminotransferase (ALT) and aspartate aminotransferase (AST), which play an important role in carbohydrate-protein metabolism, are also noteworthy (10, 11). We have shown (Table 2, Fig. 1) that during hypobiosis, the activity of aspartate aminotransferase in the blood of turtles and marmots increases, and to a more pronounced degree in turtles. Hypobiosis is also characterized by a significant activation of alanine aminotransferase, the value of which both in mammals and in reptiles as a whole is not lower than in rats (Table 3), but significantly increases under conditions of hypobiosis, especially in turtles (Fig. 2).

The results of measuring the activity of transaminases in the blood serum show that in the blood of animals with hypobiosis, there is a significant restructuring of the enzyme systems that integrate the protein and carbohydrate metabolic pathways.

Table 3.

Transaminase activity (mmol / L per second) in the blood of rats, marmots and turtles in an active state (Hereinafter, the number of animals is indicated in brackets)

Animals	**Condition**	(ALT)	(AST)
Rat		0.34±0.025 (8)	0.33±0.055 (8)
Marmot	Active	0.43±0.062 (9)	0.40±0.032 (9)
Turtle	Active	0.38±0.045 (12)	0.33±0.034 (12)

Figure-2. Relative change in transaminase activity in the blood of marmots and turtles under conditions of hypobiosis.

The ordinate is the relative activity of transaminases in hypobiosis, taken in the active state of animals for 1.0 (control).

The data presented above demonstrate a much lower level of metabolism in cold-blooded animals, as well as its greater decrease in conditions of cold stupor and hibernation; significant shifts in the indicators of carbohydrate-lipid blood metabolism in animals of these groups have been established. In this regard, we analyzed in more detail some physiological and biochemical indicators of metabolic processes in the liver tissue of turtles as a representative of cold-blooded animals in an active state and during hypobiosis.

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